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Study on Retrofitted R.C.C. Building by Different NDT Methods

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Abstract : *In this project, condition of the existing structure is assessed using NDT'S and it is proposed to extend the structure. The building was designed according to the state of the art over 40 years ago, it did not meet the present day requirement. The project study deals with strengthening and enhancement of performance of existing structure by means of Retrofitting, so that structure can perform well when it would be subjected to additional loads over it. Building is residential community building having G+2 storey. Utility or purpose of building is for society gatherings. Number of floors proposed to extend are three. The present work deals with NDT on existing structural elements, determination of load and moment carrying capacity of structural elements before and after extension, method applied for strengthening of structure and design of the existing structural elements such as R.C.C. beams and columns according to the load carrying capacity required.*
Keywords - *Confinement, jacketing, NDT test, strengthening.*

I. Introduction

A R.C.C structure is designed to have a capacity to carry combined loads (dead, live and seismic loads) at certain safety level and at certain degree of reliability. When this design is finally executed in construction process, the expected performance of the structural building should come into satisfaction. However, this ideal condition is not always realized. Almost all the structures are constructed of R.C.C and even though it is a wonderful construction material, but once set it is very difficult to increase its strength. The performance of building reduces in terms of safety level, strength or capacity due to the variety of causes or situations such as deterioration of concrete, unskilled work, alteration of building units, larger loads due to extension of structure etc. These structures behaves or performs normally during their entire life span but at the end of design period of structure, the structure may not be capable to take the existing loads and obviously it will not be possible to take the extra loads on it. This pose a more difficult scenario for a structural engineer than designing and constructing a new building. Enhancement of the performance of such a deficient buildings can be done by increasing the strength and the strength of building can be increased by the process of retrofitting. R.C.C Buildings can be made to undergo three different R's namely Repair, Rehabilitation and Retrofitting. Repair is partial improvement of the degraded strength of a building after an earthquake. Rehabilitation is a functional improvement, wherein the aim is to achieve the original strength of a building after an earthquake. Retrofitting means structural strengthening and enhancement of performance of deficient structural elements of a building to a pre-defined performance level whether or not an earthquake has occurred. The performance of a retrofitted structure is aimed higher than that of original structure. The structural elements are strengthened according to the load carrying capacity required. Retrofitting of deficient existing building to improve the performance will be a pathway to assure the future safety of the structure. There are several retrofit techniques for strengthening the structure and one of the retrofit technique named as jacketing is applied for strengthening proposed existing structure in this project. In recent years, RCC jacketing is commonly used to increase the seismic strength of a R.C framed structure, for rehabilitation of structures damaged by an earthquake or for strengthening of an undamaged structure made necessary by revision on structural design or for taking additional loads.

II. Jacketing Techniques

Jacketing is one of the most frequently and popularly used technique to strengthen reinforced concrete structures. It is mostly for strengthening the R.C columns. With this method, axial strength and stiffness of the original column is increased. Jacketing is a process of fastening durable material over concrete and filling the gap with grout. Jacketing restores the section of an existing member by encasement in a new concrete. This technique is applicable for protecting the member against further deterioration as well as for strengthening.
Strengthening of existing structures is needed when – a) Load carried by the column is increased due to either increasing the number of floors or due to mistakes in the design. b) The compressive strength of the concrete or the percentage and type of the reinforcement is not according to the codes requirement.

2.1 Jacketing of column

Column failures have caused the most significant failures of reinforced concrete structures. To prevent the column failure mechanism during earthquakes, column should never be the weaker components in the whole structure. Practical methods available for strengthening existing R.C column include adding concrete jackets, steel jackets, FRP jackets, external prestressing wires, strands or belts and steel collars.

2.2 RCC jacketing of column

RCC jacketing of column consists of adding concrete with longitudinal and transverse reinforcement around the existing columns. Additional concrete and reinforcement contributes to the increase in strength. Reinforced concrete jacketing can be employed as a repair or strengthening scheme. R.C.C jacketing increases the member size significantly, also increases the member's stiffness and is useful where deformations are to be controlled. Shear and axial load carrying capacity of the structural members can be enhanced by this method. This method provides better solution for avoiding buckling problem, if the column in building is found to be slender. The resulting cured member not only strengthens the reinforced concrete member but also acts as an excellent barrier to the corrosion agents, which are detrimental to concrete and the reinforcement. In addition, the original function of the building can be maintained, as there are no major changes in the geometry of the building with this technique.

2.3 Steps in the jacketing process

- Adding steel connectors into the existing column in order to fasten the new stirrups and vertical steel bars of the jacket at spaces not more than 50cm. These connectors are added into the column by making holes 3 – 4 mm larger than the diameter of the used steel connector and 10–15cm depth.
- Filling the holes with appropriate epoxy material and inserting the connector into the hole.
- The size of the jacket and the number and diameter of the steel bars used in jacketing process depend on the structural analysis of the column.
- Installing the new vertical steel bars and stirrups according to the designed dimensions and diameters.
- Coating the existing column with appropriate epoxy material which would guarantee the bond between old and the new concrete.
- Pouring the concrete of the jacket before the epoxy material dries. Concrete used should be of the low shrinkage consisting of small aggregates, sand, cement and additional materials to prevent shrinkage.

Fig 1. Picture showing column jacketing

III. Methods Of Ndt Test

Non-destructive testing (NDT) is defined as the determination of the physical condition of an object without affecting that objects ability. NDT methods have been in use for about 4 decades, and in this period, the development has taken place to such an extent that it is now considered as a powerful method for evaluating existing concrete structures with regard to their strength, durability and quality.

Various non-destructive methods of testing concrete have been developed:

1. Surface hardness tests
2. Rebound test
3. Ultrasonic test
4. Penetration and pull out tests

5. Dynamic or vibration tests
6. Combined methods
7. Radioactive and nuclear methods
8. Magnetic and electrical methods
9. Acoustic emission techniques

The commonly used non-destructive tests are the Rebound hammer tests and Ultrasonic pulse velocity test. So the methods used in this work are also Schmidt rebound hammer test and ultrasonic pulse velocity test.

3.1 Ultrasonic pulse velocity test

UPV is the important NDT method used for testing concrete. This method has gained considerable popularity all over the world. This method involves a measurement of travel time over a known path length pulse of ultrasonic compressional waves. The pulses are generated by use of pulse generator circuit. The pulse generator circuit consists of electronic circuit for generating pulses and a transducer. The pulses are introduced into concrete by a piezoelectric transducer and similar transducer acts a receiver to monitor the surface vibration cause by the arrival of the pulse. A timing circuit is used to to measure the time for the pulse to travel from the transmitting to receiving transducers. The path length between the transducer divided by time of travel gives the average velocity of wave. The pulse velocity is determined by the equation.

$$\text{Pulse Velocity} = \frac{Path \quad Length}{Transit \quad Time}$$

Generally, the higher the pulse velocity, the higher the quality and durability of concrete or lower quality concrete is by lower velocity.

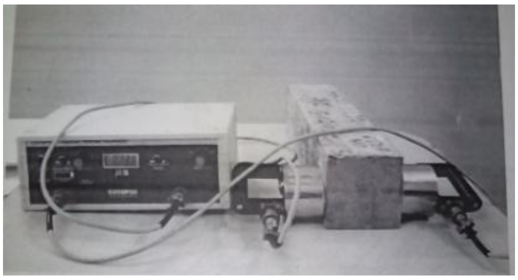

Fig 2. Ultrasonic pulse velocity instrument.

I.S. 13311-1992 code of practice for Ultra sonic pulse Velocity explains the details of pulse velocity and condition of concrete.

Table 1. Quality of concrete as per IS 13311(part I) 1992

	Ultrasonic pulse velocity (km/sec)	Quality of concrete
1	Above 4.5 km/sec	Excellent
2	3.5 to 4.5 km/sec	Good
3	3 to 3.5 km/sec	Medium
4	Below 3 km/sec	Doubtful

3.2 Schmidt rebound hammer test

Schmidt rebound hammer developed in 1948 by a Ernst Schmidt a Swiss engineer for testing concrete, based upon rebound principle when a hammer strikes concrete. The degree of rebound is an indication of hardness of concrete. It consists of a spring control hammer that slides on a plunger within a tubular housing. The plunger is extended from the body of the instrument, which causes a catch mechanism to grab hold of the hammer. The body of the instrument is then pushed towards the concrete surface which stretches the spring attached to the hammer and body. When pushed to the limit, the catch is released and the hammer is propelled towards the concrete by combination of gravity and spring forces. After then hammer strikes up to the shoulder of plunger and it rebounds. The rebound distance travelled by a spring control mass is called the rebound number and it is measured on a scale which is attached to a rider. This test can be conducted horizontally, vertically or at any intermediate angle. After knowing rebound number, the calibration chart is used which shows the relationship between compressive strength and rebound number.

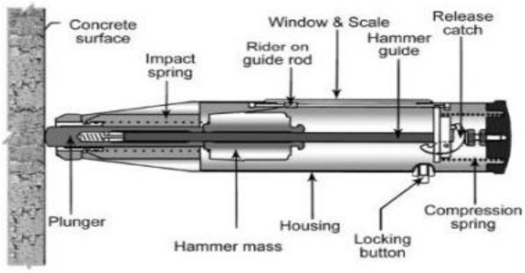

Fig 3. Schmidt rebound hammer instrument

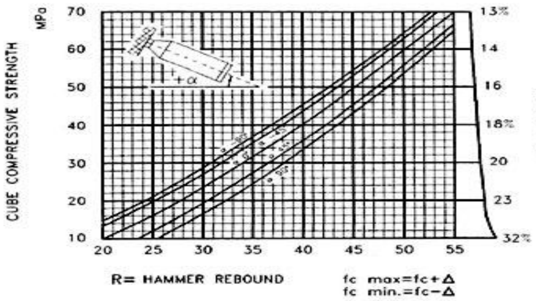

Fig 4. Calibration chart

3.3 Picture showing performance of NDT test

Fig 5. Performance of UPV & Schmidt rebound hammer test

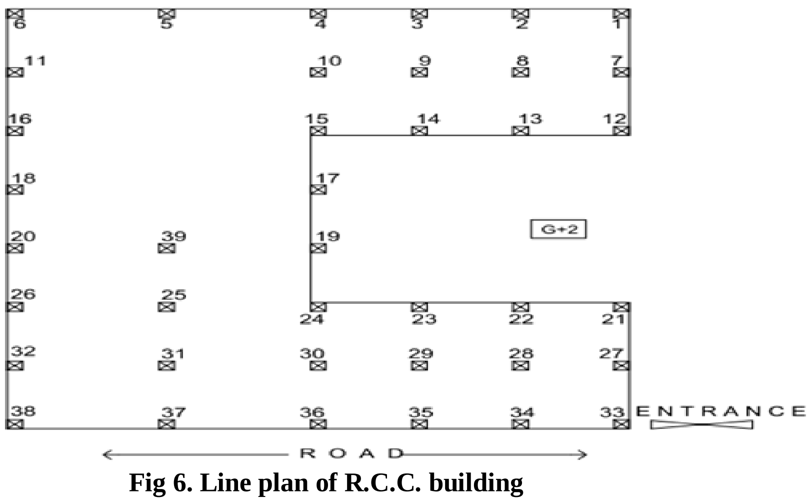

Fig 6. Line plan of R.C.C. building

IV. Results

To evaluate concrete condition of R.C.C structure, we have performed Ultrasonic Pulse Velocity test and rebound hammer tests on various R.C.C members.

Table 2: Schmidt rebound hammer test result

Sr. No.	Particulars	Rebound No.	Average	Compressive Strength in N/mm^2
1	C-13	36,32,24, 28,26	29.2	22.1
2	C-08	30,28,26, 30,28	28.4	20.6
3	C-02	34,28,32,30,28,26	29.6	22.2
4	C-10	34,30,26, 28,20	27.6	18.8
5	C-15	36,32,28,22,22	28	20.2
6	C-17	34,32,30,26,26	29.6	22.4
7	C-19	32,28,26,22,32	28	20.2
8	C-23	34,30,24,26,22	27.2	18.4
9	C-39	24,28,34,26,22	26.8	18
10	C-20	28,24,2634,24,32	28	20.2
11	C-18	32,32,30,28,24,26	28.6	20.8
12	C-16	34,30,28,30,28,24	29	22
13	C-11	32,26,32,22,36,20	28	20.2

Based on the NDT results:

- As per the Non destructive Tests carried out on existing structure, it is observed that the Ultrasonic Pulse Velocity Results with direct, semi direct and indirect methods indicates the maximum readings are below 3km/sec and between **3.0 km/sec to 3.5km/sec**.
- As per the Ultrasonic pulse velocity test (refer to IS 13311 (Part I) 1992 "Non –Destructive Testing of concrete methods of test, Ultrasonic Pulse Velocity").It is observed that quality of concrete is **medium and doubtful.**
- As per Rebound Hammer test (refer to IS 13311 (Part II) 1992 "Non- Destructive Testing of concrete - methods of test, Rebound Hammer") the readings of Rebound Hammer indicates the probable compressive strength of concrete is **M18 TO M22.**

V. Conclusion

The project study deals with strengthening and enhancement of performance of existing structure so that structure can perform well when subjected to additional loads over it. The present work deals with NDT on existing structural elements/determination of load and moment carrying capacity of structural elements before and after extension, method applied for strengthening of structure ,design of the existing structural elements such as R.C.C beams and columns according to the load carrying capacity required.

This work can be further extended to:

- Strengthening of the existing structure with different retrofitting techniques.
- Study on the performance of the existing structure after retrofitting.
- Study can be done by increasing the additional floors on existing structure and requirement of strengthening for that.
- Study of R.C.C. column may be checked by different NDT methods.

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